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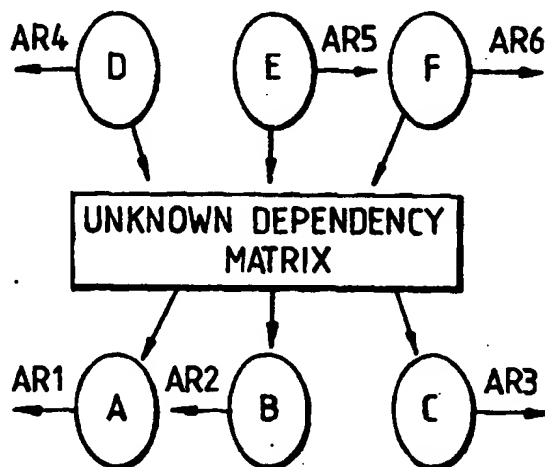
(57) Abstract

Simultaneous events reported to an equipment management system are compared with historical data in order to establish whether there is a relationship between the events. Historical data is used to determine the statistical probability of the events occurring independently simultaneously. If this probability is below a predetermined threshold this will suggest that the events are not independent, but are related. Such relationships are alerted to an operator, for example by highlighting or grouping on a screen display, assisting the operator in identification of related events, without the need for prior knowledge of the relationships in the system. The events may be alarms generated by faults in a network. The identification of related faults at different points in the network assists identification of their common cause. The historical database may be updated by further event occurrences as they are reported to the equipment management system, thereby enlarging the database to make the results more statistically accurate. Events may be reported to the system automatically or by human agency. To allow for systematic delays in event reporting, alarms from one source may be compared with alarms from another source occurring a fixed time later or earlier.

EVENT CORRELATION

This invention relates to the operation of equipment management systems.

5　These systems are used for monitoring, and in some cases also controlling, the operating states of interacting equipments such as are found in communications networks or large industrial complexes. The present invention was devised with telecommunications networks in mind, but it can
10　be applied to other systems having a large number of interacting equipments. In an equipment management system, monitoring devices sense the operating states of the various equipments and send signals to an equipment manager in response to significant events in the operation of their
15　respective equipments. Signals may also be sent by human agency to report conditions in the equipment. The term "event" will be used in this specification to signify any state, or change in state, causing such a signal to be sent. In general these events will be faults and the monitoring
20　devices will be fault detectors for sending alarm signals to the equipment management system in the event of a fault being detected.

　　For example, in a telecommunications network, an alarm signal caused by the failure of a switching centre would
25　alert the system manager who would arrange for alternative routings to be made and who would also arrange for any necessary repair work to be done on the faulty switching centre. In some systems these responses may be automated, but more usually the faults will require human intervention,
30　the system merely providing to the system manager details of any faults requiring attention. This allows the manager to organise the available resources efficiently, taking into account factors such as safety-criticality, priority, and the whereabouts of field staff.

35　This also allows non-significant alarms with known causes, such as those caused by equipment having been

- 2 -

disconnected for routine maintenance, to be disregarded by the system manager.

It is well established that effects of a network failure, such as the failure of a high bit rate line system,
5 will propagate down through a hierarchy of dependent resources and initiate many nearly simultaneous alarm messages. Time and other resources can be wasted by investigating the sources of all the alarms if the underlying cause has not been identified.

10 A fault may affect all equipment directly connected to the source of the fault, or all equipment at one geographic location, (although they may be topologically remote from each other) or all equipment of a specific type. For example, external radio interference could affect all
15 radio links in the network operating on a specific frequency within radio range of the source of interference although, from the point of view of connectivity of the network, they may appear remote from each other. Based upon this understanding it is known that alarm messages that occur with
20 close temporal proximity will tend to be associated or correlated.

The size of any temporal window within which alarm messages are considered as correlated has to be optimised - if it is set too large, the chance of alarm messages from
25 unconnected resources arriving within the temporal window increases; if it is set too small, only a subset of the dependent alarm messages might arrive within the temporal window.

In certain circumstances, related faults may only be
30 detected by the system at a later time. For example, this will be the case if an equipment not in operation at the time of the initial fault later attempts to establish contact with the failed equipment.

The operator of the network will be able to determine
35 an appropriate window size according to the characteristics of the network. This will depend on the nature of the network and the faults being monitored within it. In

- 3 -

circumstances where faults are reported to the system by
human agency rather than automatically, or in which their
exact timing is difficult to measure, the window may be of
the order of hours, or even days, whereas for systems
5 continuously and automatically monitored a suitable time
window may be.measured in seconds.

Of course, the mere fact that two events have occurred
together on one occasion is not necessarily indicative that
there is a causal relationship between them. Whatever
10 optimised temporal window is selected, there remains a finite
probability that two or more independent alarm hierarchies
will report within the same temporal window.

For convenience in the following discussion, events
occurring in the same temporal window will be referred to as
15 simultaneous.

Although temporal correlation within a single window
is a simple technique to implement, it provides no great
confidence that a dependency actually exists between alarm
messages. Simultaneity cannot prove dependency and hence
20 cannot identify a cause and effect relationship between alarm
messages.

In known equipment management systems these problems
have been approached by building up a computer model of the
system, or relying on the knowledge of the operators. This
25 requires detailed and up to date knowledge of the system and
its accuracy depends on recognition on all of the factors
which may be involved. Moreover, any such model would be
specific to the individual equipment, and have no general
applicability. The present invention addresses these
30 disadvantages by employing an empirical approach to
identification of related alarm events.

According to a first aspect of the present invention,
there is provided a method of identifying likely
relationships between events occurring in equipment managed
35 by an equipment management system which includes: storing
historical data concerning the times that specified events
occur in the equipment during a reference time period;

- 4 -

identifying further occurrences of the specified events, analyzing the historical data to determine a measure of the relatedness between the further event occurrences, and providing the measure to an output means of the equipment
5 management system.

This invention removes the need to build up a model of the system in advance. In one arrangement according to the invention, the historical data may be updated, allowing the method to "learn", allowing it to improve in accuracy as the
10 database increases in size and to keep up with changes made to the system. It thus identifies events which are likely to be related, in the sense either that one is a direct consequence of the other, or that they have some common underlying cause. Although the events monitored will usually
15 be fault alarms generated by devices monitoring the components of the equipment being managed, other events which could be related to such faults may also be input to the system, such as data from meteorological sensors, or faults reported to the management system by human agency, e.g. in
20 response to a report from a remote user.

Significant power can be added to the prior art single window temporal correlation by using historical event data in this way to identify a probable relationship between event occurrences. Such dependencies can be identified through the
25 use of a historical temporal correlation technique, according to the present invention, without prior knowledge of any relationship between resources.

Preferably a predetermined temporal window is defined and the further events are selected from the events occurring
30 within the temporal window.

The measure of relatedness is preferably the statistical probability of the further events having occurred within the same temporal window by chance.

In one arrangement the relatedness of a selected event
35 with two or more other events is measured, and the two or more other events are ranked in order of said statistical probabilities.

- 5 -

The output means is preferably a display, and events are selected for display only if said statistical probability is below a threshold value.

In such a display, displayed events may be highlighted
5   if said statistical probability is below a threshold value, which may be a predetermined value, or may be selected according to criteria dependent on the range or pattern of said statistical probabilities.

The selected event is preferably selectable from
10   amongst the different events identifiable by the system.

In a preferred embodiment the equipment management system monitors the equipment to be managed and detects the occurrence of the events.

However, at least some of the events may be identified
15   to the system by human agency.

The historical data may be stored by
- selecting a reference time period, and
- dividing the reference time period into temporal windows of a predetermined size, and
20   - for each event to be analyzed, storing the identity of each temporal window within the reference time period during which that event occurs.

The analysis procedure may proceed as follows:-
25   - one of the temporal windows is selected to be analyzed;
- a first event occurring in the selected temporal window is selected;
- other events occurring in the selected temporal window
30   are identified; and
- for each such other event, the stored identities of temporal windows in the reference time period in which the events occurred are used to calculate a statistical probability of such other event occurring by chance in the
35   same temporal window as said first event.

An alternative analysis procedure is as follows:-

- 6 -

one of the temporal windows is selected to be analyzed; a first event occurring in the selected temporal window is selected;

other events occurring in a second temporal window
5   related to the selected temporal window by a predetermined relationship are identified; and

for each such other event, the stored identities of temporal windows in the reference time period in which the events occurred are used to calculate a statistical
10 probability of such other event occurring by chance in a temporal window having the same predetermined relationship to a temporal window in which the first event occurs.

The predetermined relationship is preferably a time difference.
15 The measure of probability of the events AR_m and AR_n occurring be chance in the same temporal window can be determined by: -

$$\frac{k!}{p!\ (k-p)!}\ r^P\ (1-r)^{(k-p)}$$

where
20   k = number of temporal windows in which an event of
            the first class occurs.
        r = number of temporal windows in which an event of
            the other class occurs.
        p = number of temporal windows in which events of
25   both the first class and the other class occur
            together.

The reference time period may be fixed, or it may be continuously updated.
30   The events are, for example, fault conditions in a system.

Analysis may be done retrospectively, after the faults have been cleared, in order to identify the root cause of the fault in order to identify the unreliable component causing

the others to fail.   Alternatively, analysis may be done in
real time, during the fault condition, in order to locate and
repair the cause of the failure, which may result in the
clearance of the other fault reports without a technician's
5   attendance being required.

The invention relies, in a preferred embodiment,
on an analysis of the statistical probability of the
simultaneous occurrence of the events. In essence, it relies
on the fact that there is a very low probability of two
10 independent events, both themselves rare, occurring
simultaneously. It follows that if there is nevertheless a
history of two rare events occurring simultaneously, it is
probable that the events are not independent, and that there
is a relationship between them.   In this method the measure
15 is the probability of the two events occurring by chance
simultaneously. The method may be used to compare events
selected pair-wise by the operator for possible matches, but
in another arrangement the comparison is made between all
events occurring simultaneously, which are then ranked in
20 order of their calculated probability of having occurred
together at one time by chance. These will generally fall
into two groups, those with a high probability of having
occurred together by chance, and those with a much lower
probability, indicating that their simultaneity is unlikely
25 to be a random coincidence, and that it is likely that there
is a relationship between them. For a large system with many
potential relationships to be assessed, some way of
distinguishing such events is desirable.

The method may include the display of events in rank
30 order, highlighting correlated events on a screen display, or
displaying only events which are correlated. The threshold
level below which a causal relationship is likely may be
predetermined, or it may be varied depending on the pattern
of probabilities determined on a case-by-case basis. This
35 threshold level can determine which events are to be
displayed or highlighted.   Two or more thresholds may be

used, to identify different levels of certainty in the correlation.

Although the reference time period may be fixed it is preferable for the data to be continuously updated. This

5 allows the system to learn and as the database becomes larger, it should become more reliable.

In some circumstances there may be a systematic delay between a report of a cause and a report of an effect, or between reports of two effects from a common cause. In

10 systems where this is likely, the method may be repeated with the time windows staggered for the two events to be compared, for example such that an occurrence of a first event in a given time window is compared with an occurrence of a second event in the immediately previous window.

15   According to a second aspect of the invention, there is provided an equipment management system comprising monitoring means for identifying events occurring in the equipment to be managed by the system; storage means for storing historical data relating to such events; input means

20 for selecting an event for correlation from among those identified by the monitoring means; correlation means for correlating the selected event with the other events identified by the monitoring means using the historical data stored in the storage means; and display means for displaying

25 the correlations determined by the correlation means.

The system may include updating means for allowing the data held in the monitoring means to be added to that in the storage means, thereby allowing the data in the storage means to be kept up to date. The correlation means preferably

30 performs a statistical correlation.

Means may be provided for allowing events to be reported to the monitoring means by human agency, eg. by a keyboard. This may be necessary, for example, if an alarm itself failed.

35   The display means preferably displays the events in such a way that correlated events can be visually

- 9 -

distinguished from uncorrelated events, for example by highlighting them.

The invention will now be described by way of example with reference to the accompanying drawings, in which: -

5   Figure 1 is a diagrammatic representation of a simple network to which an embodiment of the method of the invention is to be applied for illustrative purposes to determine the interdependency;

Figure 2 is a diagrammatic representation of

10 illustrative historical alarm data for the network of figure 1;

Figure 3 is a diagrammatic representation showing the network of figure 1 with the interdependencies determined by the embodiment of the method of the invention;

Figures 4a 4b and 4c show dependency 'league tables'

5 representative of the results obtainable by the method of the invention;

Figure 5 is a representation of a display produced by the method of the invention, performing a second exemplary correlation according to the invention; and

10   Figure 6 is a diagrammatic representation of an apparatus for performing an embodiment of the invention;

To assist the understanding of this description of embodiments of the invention it will first be applied to the simple network of Figure 1 which has only six resources

15 A, B, C, D, E and F and a reference time period divided into only ten temporal windows (t-9 to t0).

AR1, AR2, AR3, AR4, AR5, AR6 are the possible alarms generated by the resources.

Figure 2 shows an exemplary historical sequence of the

20 alarm messages which are taken to have arrived from each resource over the reference time period.

Following the method of the invention, an event occurrence is selected by the operator for analysis. In this example alarm AR1 occurring in temporal window t0 is

25 selected. In this example all other events AR2 to AR6 occurred, simultaneously with AR1, in this window.

- 10 -

The probability (r) of each event occurring is obtained from the historical data by calculating the number of windows in which it occurred (X) divided by the total number of windows in the reference time period (n), i.e. 0.5
5 for AR1, AR2 and AR5; 0.1 for AR3 and AR6 and 0.9 for AR4.

Events AR2, AR4 and AR5 each occur simultaneously with AR1 five times, whilst AR3 and AR6 occur simultaneously with AR1 only once.

A dependency between two resources will tend to exist
10 if their respective historical alarm sequences have a low probability of being similar by pure chance.

The probability of two historical alarm sequences, $AR_m(t)$ and $AR_n(t)$, being similar by chance may be calculated from the Binomial distribution:
15

$$. P(AR_m(t) \text{ and } AR_n(t) \text{ similar}) =$$

$$\frac{k!}{p! \ (k-p)!} \ r^p \ (1-r)^{(k-p)}$$

where:

k = Number of temporal windows where AR_n is active.
20   p = Number of temporal windows where AR_m and AR_n are active

r = Probability of AR_m being active
when testing dependency of AR_n upon AR_m.

r is determined empirically by the method, by calculating
25 x/n, where n is the total number of temporal windows, and x is the number of windows in which ARm is active. Having calculated the probability of each pair of alarms ARm, ARn occurring together by chance, the pairings can be ranked in order of their probability to form a 'league table' of
30 relatedness.

The probabilities of correlation as given by the formula above are shown in the tables of figure 4a to 4c, in increasing order of size. It will thus be readily seen from

- 11 -

figure 4a that the least likely alarms to have occurred simultaneously with AR1 by chance (and thus the most likely to be related), are AR2 and AR5.

5   A decision thresholding can be applied to determine where the break point between a dependent and non-dependent probability should lie.   This threshold may be pre-determined, or it may be calculated on the basis of the clustering of results.   For example, figure 4a shows the dependency league table produced by performing the historical

10   temporal correlation of AR1(t) with all resources shown in figure 1.

AR2 and AR5 can be shown to fall within the same dependency hierarchy as AR1 itself.

The double line in figure 4a indicates where the

15   dependent/non-dependent threshold should be applied.   The probability of alarms being similar are clustered in two groups with a change by an order of magnitude across this threshold.   In an operator's display, the area of the screen 2 above the threshold might be highlighted in some way.

20   Alternatively, the correlated events may be the only ones displayed.

The method can be repeated selecting another alarm for comparison against the others.

For AR3 it can be determined that the probability of

25   random correlation with AR6 is 0.1, whilst the probability of random correlation with any other resource is greater than 0.3 as shown in figure 4b.   Similarly, using AR4, it can be determined that all correlations have probabilities of random occurrence of at least 0.24.   It can thus be seen that event

30   AR4 is not correlated with any other.   These results are shown in figure 4c.

In the simple network of figure 1, one can see from visual inspection of figure 2 that these results are intuitively reasonable.   A visual inspection of all

35   historical alarm messages shows that the historical pattern of AR1(t) is similar to those of both AR2(t) and AR5(t) but is very different from those of AR3(t), AR4(t) and AR6(t).

- 12 -

AR3(t) has a pattern similar to that of AR6(t) but is very different to all other alarm sequences.

Although all resource alarms were temporally correlated in window t0, the historical temporal correlation of these alarm sequences would show that AR1 and AR2 were probably related to AR5 and that AR3 was probably related to AR6 (figure 3). No alarms appeared to be related to AR4.

However, in more complex systems having perhaps many hundreds of resources, such visual analysis is impossible. Moreover, in real networks alarm signals occur at a much lower frequency than in the example and thus the number of time frames needed to provide a statistically useful database will be very large. Furthermore, although it would be possible for a skilled operator to manually sub-group many of these alarms, the data is not presented in prior art systems in a way that enables the most significant alarm (ie. the one upon which most other alarms are dependent upon) to be identified. The method of the invention is thus particularly suited for use in large systems where the number of possible correlations is too great to group intuitively.

When the probability of an event occurring (r) is small the Binomial distribution used in the first example approximates to the Poisson distribution:

$$P(AR_m(t) \text{ and } AR_n(t) \text{ similar}) = \frac{(k\ r\ )^p}{P!} e^{-(k\ r)}$$

As a second example, using real data, a one-off historical temporal correlation was performed between a selected resource in the BT Network Monitoring System (NETMON) which reported a fault at 10:53:43 on a certain date, and all other resources in the system reporting within the same window. The historical database comprises all December 1990 alarm data (fault reports), using a 150 second window size, thus giving 17,856 windows. The national NETMON database for December 1990 holds about 2×10^6 alarms from about 40,000 resources. Clearly the identification of historical

- 13 -

patterns from such quantities of data cannot be done by
simple inspection

In this example a threshold value will be determined
in advance. From the figures above it can be seen that the
5 average number of alarms per resource in the reference period
is approx. 2,000,000/40,000=50, and the average probability
of occurrence in any given temporal window is thus
50/17856=0.0028. Thus the probability of any randomly
selected pair of resources reporting simultaneously in a
10 given window is of the order of $(0.0028)^2=7.8x10^{-6}$. There
are $(40,000)^2 = 1.6x10^9$ possible pairings of resources, so
there will be approximately 12,500 random correlations in any
given temporal window.

To   avoid   being   overwhelmed   by   these   random
15 correlations, a threshold value is chosen which only reports
the most statistically significant correlations.   In the
following example a threshold probability of 10^{-8} is used.

Figure 5 shows the top of the dependency "league
table" resulting from performing the correlation method
20 according to the invention on this data.   This may be
displayed on screen 1 (Figure 6).   The top entry in the
league tables is in respect of the fault reported by the
selected resource.   The threshold value lies off the bottom
of this fragment of the table.

25   The table has five columns.   The first column
indicates the region in which the fault is located: NE =
North East, S = Scotland, M = Midlands, L = London, NW =
North West.

The second column specifies the actual origin of the
30 alarm.

The third column indicates the nature of the fault
prefixed by a two letter code indicating the location of the
fault. (Note that the system may be alerted to a fault at a
location remote from the fault itself.

35   The fourth column calculates the probability of the
alarm fault occurring by chance.

The fifth column gives the correlation probability.

- 14 -

From their positions in this league table, it becomes easy to identify many associations between resources within an alarm dependency hierarchy, which would not otherwise be apparent.

5   Faults within this hierarchy are seen having the prefix codes (column 3) for Leicester (LE), Leeds (LS), Sheffield (SF), Edinburgh (EH), Cambridge (CB), London (L), Manchester (MR), etc. Some of the correlations revealed by this league table have obvious causes: for example the first

10   thirteen all occur in the same location as the selected source. However, it is also possible to see that alarms emanate from three line systems all radiating from the same place coded LE/D (Leicester D): Leicester D - Derby F, Leicester D - Leeds G and Leicester D - Sheffield E. The

15   apex of this dependency hierarchy appears to be a power related effect.

The results from this exemplary historical temporal correlation suggest that a problem with the power supply ar the location coded LE/D is responsible for many alarms

20   occurring over a wide geographical area. This conclusion could not have been drawn by looking at the results of a prior art single window temporal correlation because of the large number of unrelated alarms also present, but can be identified more easily from the ranking determined by the

25   method of the invention.

Post analysis revealed that in this case a fault was indeed present in the power supply to part of the network in the Leicester area.

The principles of historical temporal correlation used

30   in the present invention can be used by a network management system as a technique for self-learning of alarm dependencies. Artificial neural network principles provide one framework within which the self learning of alarm dependencies could function.

35   By recording correlations as they are identified, the system can build up a computer model of the dependencies so

- 15 -

that when particular patterns of alarms next occur it can
more readily identify alarms as being related.

A network management system according to the invention
is shown in figure 6. There is shown a network of resources
5 R1 to R9 having a number of interconnections. Resources R1
to R8 have respective monitors AR1 to AR8 which report alarm
conditions to the network monitoring means 2 for display to
the operator 3 on screen 1. Resource R9 is not directly
connected to the management system but field operative 4
10 discovering a fault occurring in resource R9 can advise the
operator 3, e. g. by telephone connection T, so that the fault
condition can be reported to the monitoring means 2 by means
of data input means 5 and input link 12.

Under the control of clock 9, the alarm conditions are
15 periodically reported through updating link 11 to store 6,
with their time of occurrence.

On observing from screen 1 a fault with which he or
she wishes to correlate other faults, the operator 3 may use
the input means 5 to select an alarm condition to be
20 correlated. The information on the current alarm conditions
is extracted from the monitoring means 2 by correlation means
7. Correlation means 7 extracts the historical data from
store 6 and performs a statistical analysis (as described
above) to calculate for each alarm currently reported to the
25 monitoring means 2, the theoretical probability of it
occurring at the same time as the selected alarm. The alarms
are displayed in ascending order of probability on screen 1.
Alarms having a probability of correlation below a
predetermined value are identified by highlighting 8.
30 The monitoring means 2, screen 1, input link 12, clock
9, updating link 11, store 6 and correlating means 7 may be
implemented as a computer provided with appropriate software.

CLAIMS

1.   A method of identifying likely relationships between events occurring in equipment managed by an equipment management system, which method includes: storing historical

5 data concerning the times that specified events occur in the equipment during a reference time period; identifying further occurrences of the specified events; analyzing the historical data to determine a measure of the relatedness between the further event occurrences, and providing the

10 measure to an output means of the equipment management system.

2.   A method according to claim 1, wherein a predetermined temporal window is defined and the further events are selected from the events occurring within the temporal

15 window.

3.   A method according to claim 2, wherein the measure of relatedness is the statistical probability of the further events having occurred within the same temporal window by chance.

20 4.   A method according to claim 3 wherein the relatedness of a selected event with two or more other events is measured, and the two or more other events are ranked in order of said statistical probabilities.

5.   A method according to claim 3 or 4 wherein the output

25 means is a display, and events are selected for display only if said statistical probability is below a threshold value.

6.   A method according to claim 4 or 5, wherein the output means is a display and displayed events are highlighted if said statistical probability is below a threshold value.

7.   A method according to claim 5 or 6, wherein the
threshold is a predetermined value.

8.   A method according to claim 5 or 6, wherein the
threshold is selected according to criteria dependent on the
5   range or pattern of said statistical probabilities.

9.   A method according to any one of claims 4 to 8,
wherein the selected event is selectable from amongst the
different events identifiable by the system.

10.   A method according to any preceding claim, wherein the
10   equipment management system monitors the equipment to be
managed and detects the occurrence of the events.

11.   A method according to any preceding claim, wherein at
least some of the events are identified to the system by
human agency.

15   12.   A method according to any of claims 3 to 10, wherein
the historical data is stored by
             selecting a reference time period, and
             dividing the reference time period into temporal
             windows of a predetermined size, and
20   for each event to be analyzed, storing the
             identity of each temporal window within the
             reference time period during which that event
             occurs.

13.   A method according to Claim 12, in which one of the
25   temporal windows is selected to be analyzed;
a first event occurring in the selected temporal window is
selected;
other events occurring in the selected temporal window are
identified;
30   and, for each such other event, the stored identities of
temporal windows in the reference time period in which the
events occurred are used to calculate a statistical

probability of such other event occurring by chance in the
same temporal window as said first event.

14.   A method according to Claim 12, in which one of the
temporal windows is selected to be analyzed; a first event
5   occurring in the selected temporal window is selected;
other events occurring in a second temporal window related to
the selected temporal window by a predetermined relationship
are identified;
and, for each such other event, the stored identities of
10 temporal windows in the reference time period in which the
events   occurred   are   used   to   calculate   a   statistical
probability of such other event occurring by chance in a
temporal window having the same predetermined relationship to
a temporal window in which the first event occurs.

15 15.   A   method   according   to   Claim   14   in   which   the
predetermined relationship is a time difference.

16.   A method according to claim 13, 14 or 15, wherein the
statistical probability of the events AR_m and AR_n occurring by
chance in the same temporal window is given by

$$\frac{k!}{p! \ (k-p) \ !} \ r^p \ (1-r)^{(k-p)}$$

20 where

        k =   number of temporal windows in which AR_m occurs.

        r =   probability of event AR_m being active.

        p =   number of temporal windows in which events AR_m and
             AR_n both occur when testing depending of AR_n upon
25   AR_m

17.   A method according to any of Claims 12 to 16 wherein
the reference time period is fixed.

18. A method according to any of claims 12 to 16, wherein the reference time period is continuously updated.

19. A method according to any preceding claim, wherein the events are fault conditions in a system.

20. A method of operating an equipment management system in order to identify relationships between two or more events substantially as described.

21. An equipment management system comprising monitoring means(2) for identifying events occurring in the equipment(AR1-AR9) to be managed by the system; storage means(6) for storing historical data relating to such events; input means(5) for selecting an event for correlation from among those identified by the monitoring means(2); correlation means(7) for correlating the selected event with the other events identified by the monitoring means(7) using the historical data stored in the storage means(6); and display means(1) for displaying the correlations determined by the correlation means.

22. A system as claimed in claim 21, including updating means(11) for periodically supplying data held in the monitoring means(7) to the storage means(6).

23. A system as claimed in claim 21 or 22 wherein the correlation means performs a statistical correlation.

24. A system as claimed in claim 21, 22 or 23 further comprising input means(5,12) for reporting events to the monitoring means(2) by human agency.

25. A system as claimed in any one of claims 21 to 24 wherein the display means(1) includes means for visually distinguishing(8) events which are correlated from those which are not correlated.
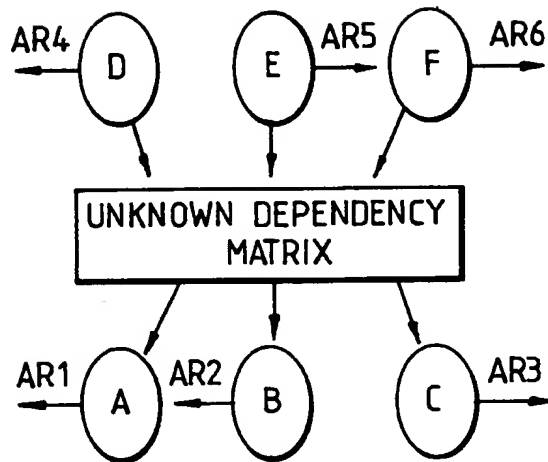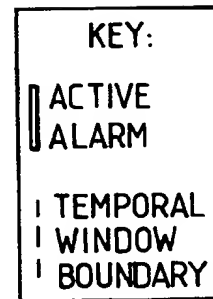
1/6

Fig.1.

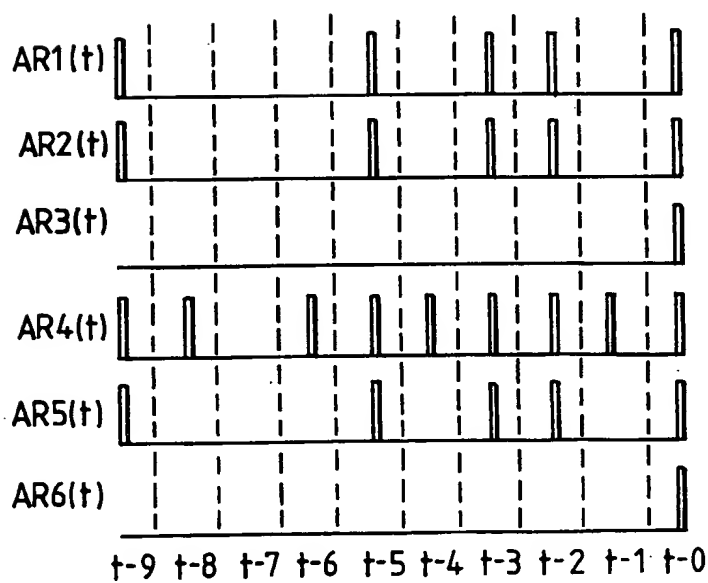# Fig.2.

Fig.3.
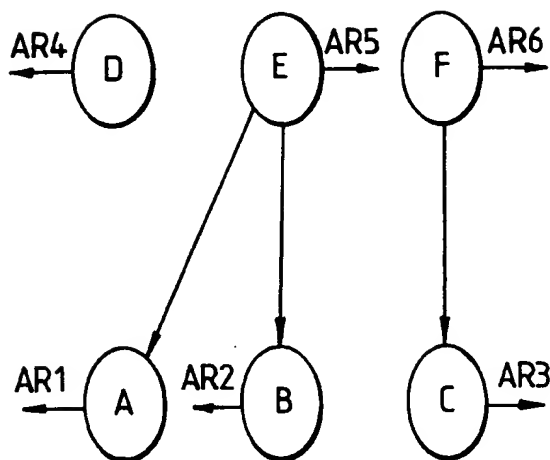
Fig.4a.

RESOURCE ARm	NUMBER OF WINDOWS AR1 & ARm ACTIVE	No. AR1 ACTIVE	PROB. ARm ACTIVE	PROB. OF COIN-CIDENCE
AR1	5	5	0.5	0.031
AR2	5	5	0.5	0.031
AR5	5	5	0.5	0.031
AR3	1	5	0.1	0.328
AR6	1	5	0.1	0.328
AR4	5	5	0.9	0.590

Fig.4b.

RESOURCE ARm	No. OF WINDOWS AR3 & ARm	No. AR3 ACTIVE	PROB. ARm ACTIVE	PROB. OF COIN-CIDENCE.
AR3	1	1	0.1	0.100
AR6	1	1	0.1	0.100
AR1	1	1	0.5	0.500
AR2	1	1	0.5	0.500
AR5	1	1	0.5	0.500
AR4	1	1	0.9	0.900

Fig.4c.

RESOURCE ARm	No. OF WINDOWS AR4 & ARm	AR4 ACTIVE	PROB. ARm ACTIVE	PROB. OF COIN-CIDENCE
AR1	5	9	0.5	0.246
AR2	5	9	0.5	0.246
AR5	5	9	0.5	0.246
AR3	1	9	0.1	0.387
AR4	9	9	0.9	0.387
AR6	1	9	0.1	0.387

Fig.5.

NETMON resource description			Alarm Arrival Rate	Correlation Probability
Rg	Origin	Designation		
NE	LSB1	LE/D8005DK 118	0.00168	2.56E-45
NE	LSB1	LE/D8007DK 119	0.00168	2.56E-45
NE	LSB1	LE/D8004DK 135	0.00168	2.56E-45
NE	LSB1	LE/D8009DK 143	0.00168	2.56E-45
NE	LSB1	LE/D3401DK 27	0.00168	2.56E-45
NE	LSB1	LE/D3402DK 34	0.00168	2.56E-45
NE	LSB1	LE/D1401DK 8	0.00168	2.56E-45
NE	LSB1	CB/E8001DK 81	0.00224	4.5E-43
NE	LSB1	CB/E3401DK 25	0.00224	4.5E-43
NE	LSB1	CB/E3402DK 26	0.00224	4.5E-43
NE	LSB1	CB/E8003DK 82	0.002352	1.08E-42
NE	LSB1	L/SS8001DK 65	0.002576	5.55E-42
NE	LSB1	L/SS8002DK 66	0.002576	5.55E-42
S	EHL	LE 8001 056	0.002016	4.04E-41
S	EHL	ACE NO 1	0.004816	4.18E-37
M	LED	LS/B1401DK 16	0.001568	2.79E-37
M	LED	LS/B3401DK 19	0.001568	2.79E-37
M	LED	LS/B3402DK 21	0.001568	2.79E-37
M	LED	LS/B8005DK 58	0.001568	2.79E-37
M	LED	LS/B8007DK 59	0.001568	2.79E-37
M	LED	LS/B8004DK 68	0.001568	2.79E-37
M	LED	LS/B8008DK 70	0.001568	2.79E-37
M	LED	LS/B8009DK 73	0.001568	2.79E-37
M	LED	LS/B8011DK 78	0.001568	2.79E-37
NE	LSB1	LE/D8011DK 262	0.00112	1.34E-33
M	LED	EH/L8001DK 40	0.004144	5.75E-31
M	LED	MR/N3411DK 193	0.001232	3.25E-30
M	LED	DY/A3401DK 5	0.001232	3.25E-30
M	LED	DY8001DK 36	0.001232	3.25E-30
M	LED	DY8002DK 38	0.001232	3.25E-30
NE	LSB1	CB/E8004DK 329	0.001344	9.23E-30

5/6

Fig.5.(cont.)

M	LED	LE/D-DY F	0.00168	1.34E-28
M	LED	LE/D-LS G	0.004928	1.55E-27
M	LED	LE/D-SF E	0.002352	7.5E-27
M	LED	SF/A1401DK 10	0.001008	1.7E-25
M	LED	SF/A3403DK 23	0.001008	1.7E-25
M	LED	SF/D3404DK 11	0.001008	1.7E-25
M	LED	SF/D8001DK 124	0.001008	1.7E-25
M	LED	SF/D8006DK 287	0.001008	1.7E-25
M	YCOK	@ ENGINE RUN	0.010529	6.19E-25
NE	LSB1	CB/E8005DK 330	0.00112	4.86E-25
M	LED	SF8004DK 22	0.001344	3E-24
NE	SFD	MR/R3404DK 3	0.001456	6.66E-24
NE	SFD	CB/E3401DK 9	0.001568	1.4E-23
NE	SFD	CB/E3402DK 14	0.001568	1.4E-23
NE	SFD	LE/D1401DK 25	0.001568	1.4E-23
L	CLB3	2-8 MUX 33-40	0.002912	2.65E-23
NE	LSB1	LE/D8008DK 231	0.000896	3.89E-23
M	YCOK	POWER DEFRRD	0.011089	1.2E-22
NW	MRR	CB/E 3402	0.005488	1.86E-22
NW	MRR	CB/E 8010	0.005488	1.86E-22
NW	MRR	CB/E 8003	0.005488	1.86E-22
NW	MRR	CB/E 8004	0.005488	1.86E-22
NW	MRR	CL 8001	0.005488	1.86E-22
NW	MRR	CB/E 8001	0.005488	1.86E-22
NW	MRR	CB/E 8002	0.0056	2.37E-22
NW	MRR	CB/E 3401	0.005712	3E-22
NW	WA1	3G MUXS 126-133	0.002464	1.26E-21
NE	SFD	MR/R8005DK* 9	0.001456	3.05E-21
NW	MRR	CB/E 8012	0.0028	4.52E-21
M	YCOK	* POWER ALARM	0.009521	1.3E-19
M	DY	DY/A-LE/D F	0.010753	5.51E-19
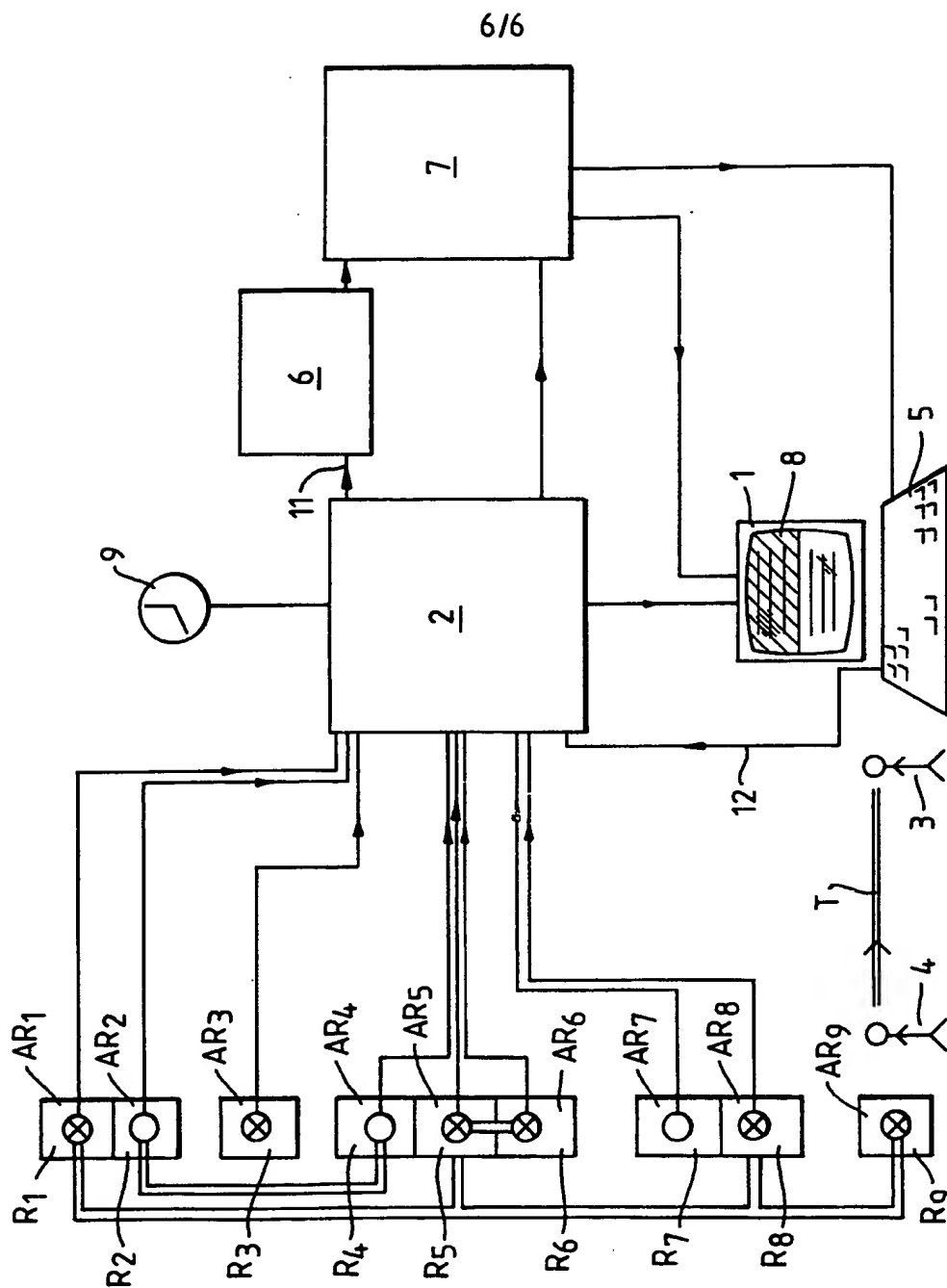
6/6

Fig.6.

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5   H04Q3/00   H04M3/24   H04M3/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5   H04Q   H04M   H04L   G08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PROCEEDINGS OF THE NINTH INTERNATIONAL CONFERENCE -ENTITY-RELATIONSHIP APPROACH- 8-10 OCT 1990 LAUSANNE(CH) pages 255 - 269 L.KERSCHBERG ET AL 'KNOWLEDGE AND DATA ENGINEERING OF A TELECOMMUNICATIONS NETWORK' see paragraph 2.1. see paragraph 4.2. see paragraph 5 --- -/--	1

[X] Further documents are listed in the continuation of box C.   [ ] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 April 1994	20. 04. 94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Vandevenne, M

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	IEEE TRANSACTIONS ON SOFTWARE ENGINEERING vol. 17, no. 9 , September 1991 , NEW YORK(US) pages 944 - 953 OURI WOLFSON ET AL 'MANAGING COMMUNICATION NETWORKS BY MONITORING DATABASES' see page 945, left column, line 1 - line 21 see paragraph 3 ---	1
A	IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS vol. 3 , 11 June 1989 , BOSTON(US) pages 1418 - 1422 DONAGHY ET AL 'MICE : A FACILITY MAINTENANCE EXPERT SYSTEM' -----	